Method for Bunch Length Measurements at the SRF Photoelectron Injector

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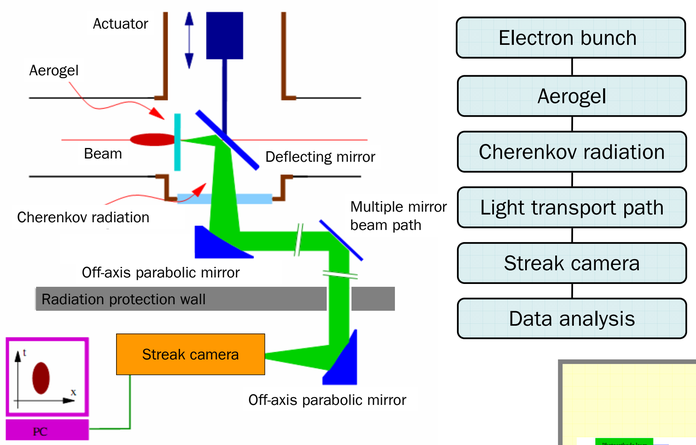
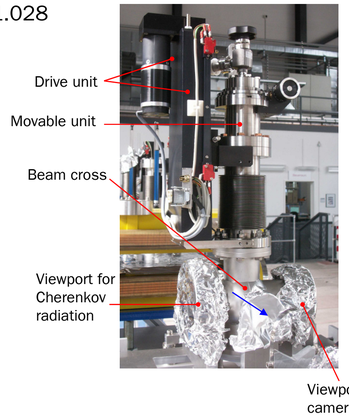
Bunch length measurement using Cherenkov radiation

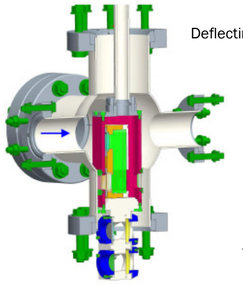
- Electron pulse length 15 ps (FWHM)
- Conversion of electron pulses to light pulses with identical temporal distribution
- Cherenkov effect as prompt radiation process; radiator material: aerogel n = 1.028
- Synchronisation streak camera to master oscillator by PLL synthesizer

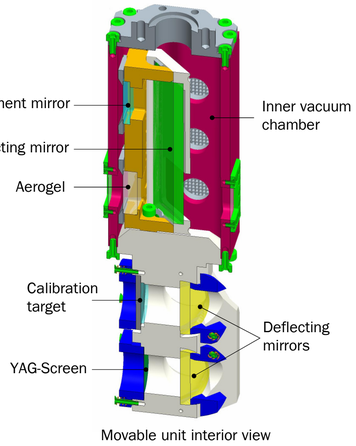


Cherenkov station

- Positioning of aerogel slice in electron beam (blue arrows show electron direction)
- Deflection of Cherenkov light of the beamline

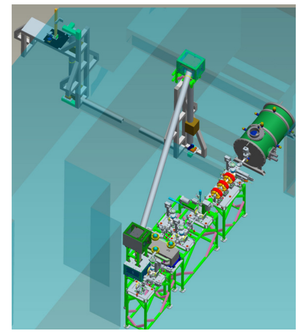


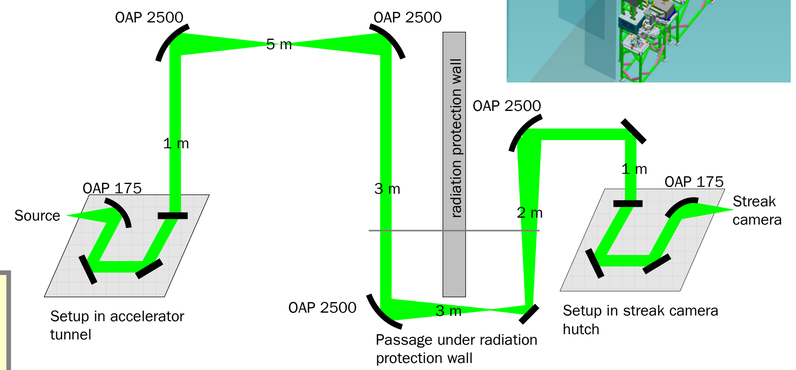




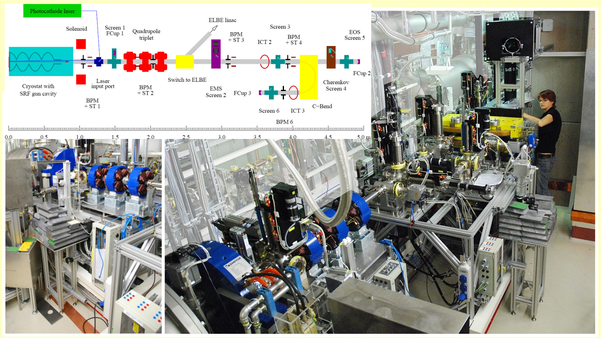
Cherenkov-beamline

- Streak camera located outside accelerator tunnel
- Light transport path about 15 m
- Fully reflective low-dispersive system
- 8 plane mirrors, 6 OAPs: focusing and collimating
- Mirror material: protected aluminium
- Problem: alignment of the optical path





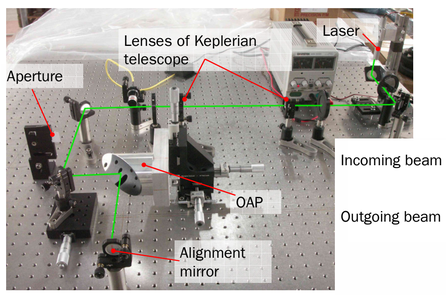
SRF Photoinjector: Diagnostics beamline and operation modes

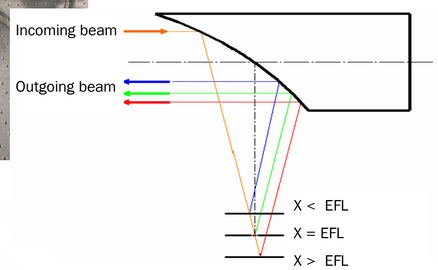


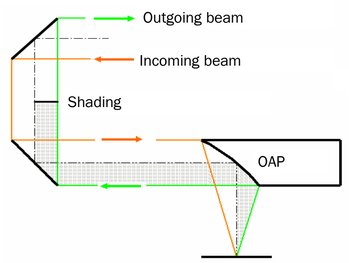
Parameter / mode	ELBE	High Charge
Electron kinetic energy	9.5 MeV	
RF frequency	1.3 GHz	
RF power	10 kW	
Photocathode	Cs_2Te	
Drive laser	263 nm	
Bunch charge	77 pC	1 nC
Repetition rate	13 MHz	500 kHz
Pulse length FWHM	4 ps	15 ps
Average current	1 mA	0.5 mA
Transverse rms emittance	1 mm mrad	2.5 mm mrad

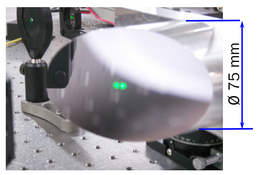
OAP Alignment

- Shading one half of the incoming laser beam
- Position of the half beams on the surface of the OAP depends on the position of the alignment mirror with respect to the focus plane
- Ideally both half beams form one uniform beam spot









Performance studies

- Estimation of signal strength and effects of dispersion by elements in the optical path

Emitted photons per electron	6
Efficiency of optical path	10 %
Electrons per bunch (1 nC)	$6 \cdot 10^9$
Actual number of photons at streak camera	$4 \cdot 10^9$
Acceptable number of photons at streak camera	$1 \cdot 10^4$

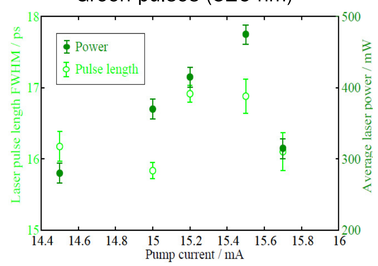
- Signal strength: 10^5 times higher than for streak camera acceptable
- Pulse lengthening due to dispersion effects: 2.2 ps (15 %)
- Correction by bandpass filter to reach max. resolution of 2 ps (limited by streak camera)

	Thickness	n(400 nm)	Δt [ps]
Aerogel	6 mm	1.028	0.04
Viewport (Cherenkov station; Fused Silica)	4.7 mm	1.47	0.5
Air	15 m	1.0003	0.7
Viewport (sealing accelerator tunnel / streak hutch; 7056 Glass / BK7	8 mm	1.53	1

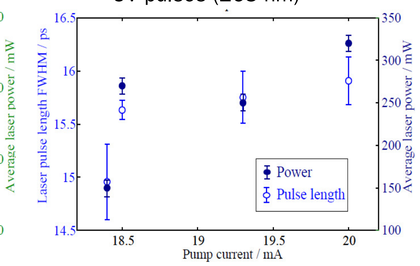
Preparative Measurements

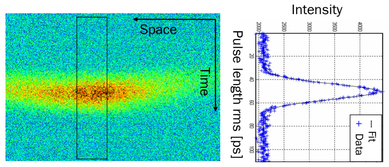
- Tests of setup and performance of the method
- Measurement of pulse length of the photocathode laser for 263 nm (UV) and 526 nm (green)
- Comparison between design values for laser pulse length and measured data
- Streak camera max. resolution 2 ps (Hamamatsu Photonics)

Green pulses (526 nm)



UV pulses (263 nm)





	Design value FWHM [ps]	Streak camera FWHM [ps]
526 nm (green)	20 ± 2	$16.4 \pm 0.5_{stat} \pm 2_{sys}$
263 nm (UV)	15 ± 1.5	$15.6 \pm 0.4_{stat} \pm 2_{sys}$

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